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A BASIS FOR A PERFORMANCE SPECIFICATION FOR WOMEN'S FULL-FASHIONED SILK HOSIERY

By

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A BASIS FOR A PERFORMANCE SPECIFICATION FOR WOMEN'S FULL-FASHIONED SILK HOSIERY

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ABSTRACT

The results of a survey on women's full-fashioned silk hosiery purchased from fourteen retail stores located in eight large cities in different parts of the United States are discussed. The brand, retail price, appearance, and construction are found to be inadequate guides to the performance of the stockings as indicated by tests on the National Bureau of Standards hosiery-testing machine, which measures the physical characteristics of the upper part of the leg of the stockings under repeated stretching.

Minimum limits for "distensibility", "recoverability", and "stretch-endurability" of the stocking; a classification of hosiery based upon the thickness of two layers of the leg fabric of the stocking; tolerances for size and length of the stocking; and a requirement for color fastness to laundering are recommended for use in a performance specification for women's full-fashioned silk hosiery.

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I. INTRODUCTION

An instrument for measuring the elastic properties of hosiery has recently been developed.[1] The performance of the instrument has been investigated by testing hosiery of known history.[2] This work indicated that the instrument is capable of measuring certain properties of hosiery which have heretofore been studied, if at all, only through the laborious and expensive process of service trials. It would seem that these properties are of direct interest to both the consumer and manufacturer, particularly the former. With a meth-

[1] Herbert F. Schiefer and William D. Appel, *Hosiery-testing machine.* BS J. Research **12**, 543 (1934) RP679.

[2] Herbert F. Shiefer and Richard S. Cleveland, *Factors affecting the performance of hosiery on the hosiery-testing machine.* J. Research NBS **14**, 1 (1935) RP753.

od for measuring them at hand, it seemed logical to apply this method to samples of hosiery selected, so as to give a representative cross section of the present market. The results of these tests should give a clear picture of the present qualities being offered, and indicate the directions along which improvement can be made.

The purchasers of hosiery at the retail counter must be guided by the following items: *Size* (length of foot)—can be had as specified. *Length*—unless the customer specifies otherwise, she may expect to get a stocking of the standard length of 30 ± 1 inch.[3] *Appearance*—she will expect to make her own selection as to color and texture, and may be given information as to the fastness of the dye. *Weight*—the hosiery will be advertised as "chiffon", "service", or some similar term. These terms are used rather loosely to indicate weight and appearance. A chiffon stocking is lighter in weight than a service stocking, and is therefore considered to have a more pleasing appearance.

Manufacturers and retailers have a more precise system of terminology, which sometimes reaches the consumer through advertising. Thus, a fine-textured chiffon stocking might be called a "3-thread, 51-gage." This expression is intended to specify the size of the yarn and the closeness of the knitting, but unfortunately these terms are not perfectly definite. The expression "3-thread" means that the silk yarn is composed of 3 threads of silk twisted together. A thread, as used in the hosiery industry, generally contains 8 to 14 silk filaments, and varies in average size from 13 to 15 deniers. In twisting together 3 such threads to make a yarn, there is the possibility of having these variations additive. Moreover, the diameter of the yarn is somewhat dependent upon the twist. The covering power of the yarn, and therefore the appearance of the stocking, may vary with this factor. The expression "51-gage" means that there are 51 needles in 1.5 inch of the needle bar, each needle producing a stitch or wale in the fabric. If the full width, 14 inches, of the needle bar were used in knitting the stocking, there would be 476 wales in the widest part of the fabric, which is above the first fashion marks. However, the fabric is extensible and may be set, by certain finishing processes, in either a stretched or shrunken condition. The number of wales per 1.5 inch in the finished stocking does not necessarily indicate that the same number of needles per 1.5 inch in the needle bar were used in knitting it. Since the term "gage" is applied indiscriminately to the fabric and to the machine, its meaning is somewhat indefinite.

II. SAMPLES

With the assistance of the National Retail Dry Goods Association, eleven stores were selected, in eight widely separated cities. Two mail-order houses and one large chain store were added to the list. The most popular, the cheapest, and usually the most-expensive style numbers were purchased from all stores. From some, all of the style numbers of a given brand were purchased; whereas corresponding style numbers of well-known brands were purchased from several stores located in the same or different cities. Of one brand, 13 style numbers were purchased. Altogether, 32 brands were represented, of which at least 15 are nationally advertised. There were 111 sam-

[3] Hosiery Lengths. BS Commercial Standard CS46-33 (1933).

ples, each sample consisting of two pairs of stockings. The information given us by the stores when the purchases were made is shown in table 1.

TABLE 1.—*Description of samples*

Lab. no.	Price	Weight	Brand	Store	Number of threads	Gage	Lab. no.	Price	Weight	Brand	Store	Number of threads	Gage
1	$0.59	Chiffon	8	4	4	42	57	$1.00	Semiservice	16	9	7	----
2	.59	do	18	7	4	42	58	1.00	do	26	10	----	----
3	.59	do	19	7	----	[1] 42	59	1.00	Medium service	4	11	----	42
4	.59	Service	8	4	7	39	60	1.00	Service	2	1	7	45
5	.69	Chiffon	20	7	4	45							
6	.69	do	27	10	----	----	61	1.00	do	5	2	6	42
7	.69	do	28	11	----	----	62	1.00	do	15	6	8	42
8	.69	do	30	13	4	39	63	1.00	do	23	12	7	----
9	.69	do	7	14	4	42	64	1.00	do	31	13	9	45
10	.69	Service	20	7	7	42	65	1.00	do	4	13	6	42
							66	1.00	do	32	14	7	45
11	.69	do	30	13	7	39	67	1.00	Heavy service	22	8	10	----
12	.69	do	7	14	7	42	68	1.15	Chiffon	3	2	3	48
13	.79	Chiffon	8	4	4	45	69	1.15	do	13	5	5	----
14	.79	do	21	7	4	48	70	1.15	do	16	6	4	45
15	.79	do	22	8	4	----							
16	.79	do	27	10	4	42	71	1.15	do	9	5	3	----
17	.79	Medium service	22	8	7	----	72	1.15	Service	14	5	10	----
18	.79	Semiservice	27	10	----	----	73	1.15	do	16	6	7	45
19	.79	Service	8	4	7	45	74	1.25	Chiffon	2	1	3	45
20	.79	do	21	7	8	42	75	1.25	do	2	1	4	45
							76	1.25	do	1	2	3	48
21	.79	do	27	10	----	----	77	1.25	do	4	2	3	45
22	.79	do	28	11	----	----	78	1.25	do	4	11	----	45
23	.85	Chiffon	11	5	----	----	79	1.25	do	31	13	3	48
24	.85	do	14	5	----	----	80	1.25	Medium service	4	11	----	42
25	.85	do	4	11	----	----							
26	.85	Medium service	4	11	----	----	81	1.25	Service	1	1	7	----
27	.85	Semiservice	24	12	7	----	82	1.25	do	1	2	6	42
28	.88	Chiffon	29	12	4	----	83	1.29	Chiffon	27	10	----	----
29	.88	Semiservice	29	12	7	----	84	1.35	do	2	1	3	45
30	.95	Sheer chiffon	22	8	----	----	85	1.35	do	17	6	3	51
							86	1.35	do	6	10	----	----
31	.95	Chiffon	25	10	----	----	87	1.35	do	4	11	----	----
32	.95	Service chiffon	22	8	5	----	88	1.35	Semiservice	6	3	7	45
33	.95	Service	11	5	8	----	89	1.35	do	24	12	6	----
34	.95	do	14	5	7	----	90	1.35	Service	12	5	11	----
35	.95	do	25	10	----	----							
36	1.00	Chiffon	5	2	3	45	91	1.35	do	25	10	----	----
37	1.00	do	1	1	4	----	92	1.35	do	28	11	----	----
38	1.00	do	2	1	4	45	93	1.35	do	24	12	10	----
39	1.00	do	6	3	4	42	94	1.35	do	4	14	8	45
40	1.00	do	8	4	4	45	95	1.50	Chiffon	5	2	3	51
							96	1.50	do	15	6	5	45
41	1.00	do	15	6	4	42	97	1.50	do	3	11	----	----
42	1.00	do	16	6	4	42	98	1.50	Medium service	3	11	----	----
43	1.00	do	23	9	4	----	99	1.50	Service	3	11	----	----
44	1.00	do	24	9	4	----	100	1.65	Chiffon	2	1	3	51
45	1.00	do	16	9	4	----							
46	1.00	do	3	9	4	----	101	1.65	do	2	1	2	45
47	1.00	do	26	10	----	----	102	1.65	do	1	2	3	51
48	1.00	do	6	10	----	----	103	1.65	do	6	3	2	48
49	1.00	do	4	11	----	42	104	1.65	do	28	11	----	----
50	1.00	do	4	13	4	42	105	1.65	do	23	12	3	[2]
							106	1.65	Service	6	3	12	42
51	1.00	do	32	14	4	45	107	1.65	do	15	6	8	45
52	1.00	do	12	5	5	----	108	1.95	Chiffon	10	5	3	[2]
53	1.00	Semichiffon	3	2	4	42	109	1.95	do	17	6	3	51
54	1.00	do	4	2	4	42	110	1.95	do	4	14	2	51
55	1.00	Semiservice	6	3	7	42	111	1.95	Service	11	5	9	[2]
56	1.00	do	24	9	7	----							

[1] 125 denier rayon.
[2] Ingrain.

III. TEST PROCEDURE

The dimensions of the stockings and their various parts, as indicated in figure 1, were measured with a scale when the fabric was lying flat on a smooth surface, without tension.

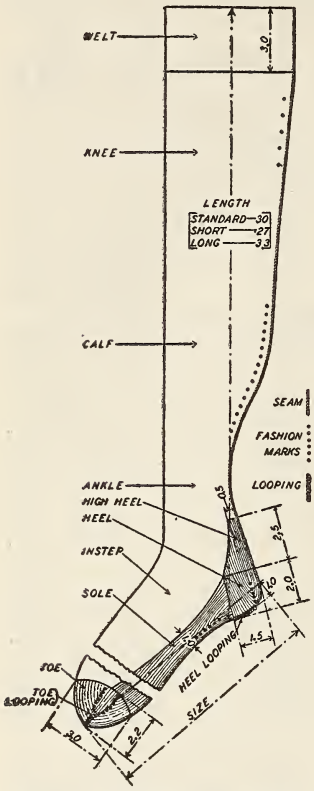

FIGURE 1.—*Schematic drawing of a full-fashioned stocking showing the different parts of the stocking and where the dimensions are measured.*

All measurements are in inches

The number of wales were counted around the circumference of the stocking immediately below the welt. Some of these, generally from 8 to 12, were taken up in the seam and could not be counted. The number and location of the fashion marks were noted as an indication of the way in which the stocking was fashioned.

The thickness of 2 layers of the leg fabric of the stocking was measured with the compressometer [4] using a circular foot 1 inch in diameter and a pressure of 1 pound per square inch. Measurements were made in three places on the leg fabric, care being taken to smooth the fabric and not to include defects, fashion marks, and the seam in the area measured. The average of the three measurements was taken to be the thickness of 2 layers of the fabric.

The weight of the leg fabric of the stocking was determined by weighing six specimens, each specimen being 2 inches square. These specimens were obtained by placing the stocking on a thin aluminum hosiery form which had three holes in it of sufficient diameter to permit cutting out areas 2 inches square with a die. The average weight of the specimens was expressed in ounces per square yard.

The stockings were laundered according to the procedure given in Research Paper RP753.[5]

The laundered stockings were tested on the hosiery-testing machine described in Research Paper RP679 [6] and the "distensibility", "recoverability", and "stretch-endurability" of the stockings were evaluated.

IV. TEST RESULTS

1. SIZE

The orders used in purchasing the stockings specified size 9.5. The sizes of the stockings measured are shown in table 2.

[4] Herbert F. Schiefer, *The compressometer, an instrument for evaluating the thickness, compressibility, and compressional resilience of textiles and similar materials.* BS J. Research **10**, 705 (1933), RP561.

[5] Herbert F. Schiefer and Richard S. Cleveland, *Factors affecting the performance of hosiery on the hosiery-testing machine.* J. Research NBS **14**, 1 (1935), RP753.

[6] Herbert F. Schiefer and William D. Appel, *Hosiery-testing machine.* BS J. Research **12**, 543 (1934) RP679.

TABLE 2.—*Sizes of stockings received*

(Size 9.5 specified)

Length of foot (inches)	Number of stockings
8.25 to 8.75	2
8.75 to 9.25	19
9.25 to 9.75	261
9.75 to 10.25	125
10.25 to 10.75	4
10.75 to 11.25	2

The extreme sizes may probably be taken as an indication that some of the stores overlooked this requirement in their orders. The intermediate variations are more serious. They raise the question as to whether or not manufacturers and retailers are using the standard method of measuring size.[7] Since sizes are designated in increments of 0.5 inch, the maximum tolerance is thereby fixed. When a customer specifies size 9.5, it is believed that she could have no reasonable objection if the stockings received measured between 9.5 and 10 inches, but she might not get satisfactory service from a stocking measuring less than 9.5 inches. The tolerance should therefore be plus 0.5 inch only.

2. LENGTH

Since the purchase orders did not specify length, it was expected that the stockings received would be of standard length, namely 30 ± 1 inch.[8]

The lengths of the stockings measured are shown in table 3.

TABLE 3.—*Lengths of stockings received*

(Length was not specified)

Length (inches)	Number of stockings
27.5 to 28.5	3
28.5 to 29.5	42
29.5 to 30.5	175
30.5 to 31.5	148
31.5 to 32.5	40
32.5 to 33.5	9
29.0 to 31.0	307 (73.6%)

These figures indicate that the standard length has been pretty generally adopted. This single-length standard was adopted to prevent misunderstandings between manufacturers and retailers, and to obviate the necessity for carrying extra stocks. Under present conditions, a retailer may be expected to carry six different sizes, in four weights and twelve different colors, or 288 varieties of the same item. If three different lengths are called for, making 864 varieties, the additional financial burden caused thereby will doubtless be passed on to the consumer. On the other hand, criticisms of the present standard indicate that a certain proportion of the customers are not satisfactorily fitted.

[7] Standardized Method of Measuring the Size of Hosiery. BS Circular C149 (1924).
[8] Hosiery Lengths. BS Commercial Standard CS46-33 (1933).

The document cited carries a footnote to the effect that shorter or longer stockings can be obtained. It might be advisable to set up three standard lengths: "Short" (27 inches), "standard" (30 inches), and "long" (33 inches). Such a procedure probably will satisfy the demands of the portion of the customers referred to, but may increase the price of all stockings.

The present tolerance of ± 1 inch should be retained. It is based upon the precision with which the manufacturing processes can be controlled.

3. CLASSIFICATION, THICKNESS, AND WEIGHT

The terms at present used to designate the "weights" of hosiery are used quite loosely, as is shown by data contained in table 4.

TABLE 4.—*Classification of stockings received*

Weight	Number of samples	Thickness range	Thread	Gage
		Inch		
Sheer chiffon	1	0.014 to 0.015, incl.	Not stated	Not stated
Chiffon	61	0.009 to 0.019, incl.	2 to 5	39 to 51
Semichiffon	2	0.014 to 0.016, incl.	4	42
Service chiffon	1	0.017 to 0.018, incl.	5	Not stated
Semiservice	9	0.019 to 0.023, incl.	6 to 7	42 to 45
Medium service	5	0.014 to 0.025, incl.	7	42
Service	31	0.019 to 0.030, incl.	6 to 12	39 to 45
Heavy service	1	0.027 to 0.027, incl.	10	Not stated

The term "chiffon" is generally taken to mean a sheer, fine' semitransparent fabric, of the desired appearance. "Service" denotes a fabric which is thicker and heavier, in which appearance has been subordinated to durability. It was therefore decided to see whether or not either the weight or the thickness could be used as a basis for classification.

The relationship between the thickness and weight of the leg fabric was determined. This relationship is shown in figure 2 in which the average thickness of 2 layers of the fabric is plotted as abscissa and the average weight of the leg fabric is plotted as ordinate. The number of threads in the silk yarn is indicated in the figure by numerals. The approximate linear relationship shown, indicates that it is not necessary to determine both the weight and the thickness. Since it is simpler, easier, and quicker to determine the thickness and since it does not require destroying the stocking, this criterion was selected for further consideration.

The frequency distribution of the individual stockings with respect to thickness is given in table 5. It shows at a glance the relationship between the number of threads in the silk yarn and the thickness of 2 layers of the leg fabric of the finished stockings. It also shows that there is some overlapping in the thickness of the stockings knit from yarns containing different numbers of silk threads. This overlapping may be caused by any one of the following factors or combinations of them: (1) number of silk filaments in each thread; (2) use of ingrain yarn, i. e., yarn which is degumed and dyed before being knit into a stocking; (3) number of courses per inch; (4) gage of knitting machine; and (5) amount of twist in the yarn.

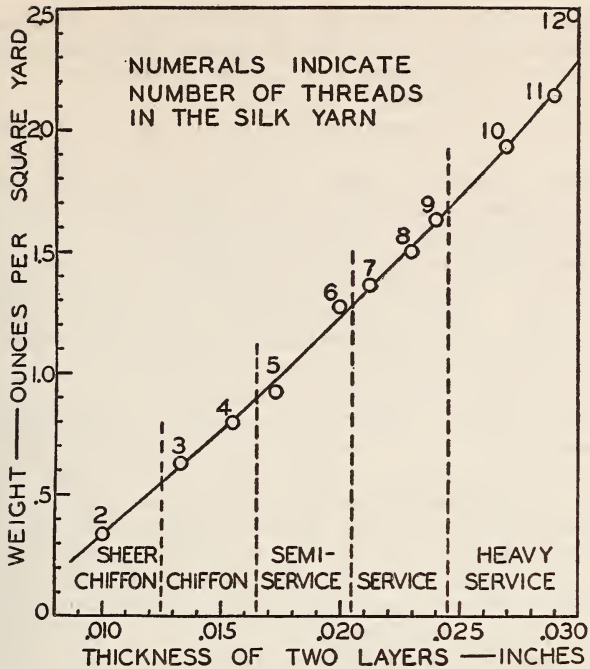

FIGURE 2.—*Relation between thickness and weight of stockings which are knit from silk yarn containing different number of threads.*

The limits for the proposed classification of hosiery are indicated by the broken vertical lines

TABLE 5.—*Frequency distribution of the individual stockings with respect to thickness*

Threads	Thickness of stocking (inch)										
	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019
2	4	1	3								
3			[a] 9	6	27	25	9				
4						10	48	44	6		
5							1	6	21	12	2
6											2
7											[b] 3

Threads	Thickness of stocking (inch)										
	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.030
6	4	2									
7	[c] 15	34	27	[d] 6	[d] 1						
8			8	13	9	2					
9			[e] 4	0	0	3	2	1			
10						1	4	5	2		
11									2	2	
12										2	2

[a] Four of these values were for stockings knit from 3-thread ingrain yarn and 4 others were for stockings knit from 3-thread yarn in which the average filament count per thread was 8.

[b] The filament count of the 7 threads for each of these stockings varied from 8 to 14.

[c] Four of these values were for stockings knit from 7-thread yarn in which the average filament count per thread was 9.7 and the total number of wales, exclusive of seam, was 347.

[d] Four of these values were for stockings knit from 7-thread yarn in which the average filament count per thread was 12.

[e] Four of these values were for stockings knit from 9-thread ingrain yarn in which the average filament count per thread was 9.6.

The number of filaments in silk threads was found to vary from 8 to 14. The thickness of the fabric increased with an increase in the average number of filaments per thread of the yarn. Specific instances are noted in table 5.

Stockings knit from ingrain yarn (dyed in the yarn) were found to be thinner than those knit from ordinary thrown silk in the gum. Two instances are noted in table 5. These stockings had the appearance of having been knit from yarns containing one or two fewer threads than were found by dissecting the yarn.

The average thickness of stockings with 45 courses per inch was 0.0006 inch more than the average thickness of stockings with 40 courses per inch. The average thickness of 45-gage stockings was 0.0004 inch more than the average thickness of 42-gage stockings. Laundering increased the thickness by 0.0006 inch.

The effect of twist in silk yarn on the diameter has been determined by Huber and Macia.[9] Their results, which are based upon microscopic measurements, show that for 2 yarns, which differ by 1 thread (e. g., 3 and 4 thread) to have the same diameter, the twist in the heavier yarn (4 thread) must be 4 times the twist in the lighter yarn (3 thread) for 2-, 3-, and 4 thread yarns and must be 2 times the twist in the lighter yarn for 7-, 8-, and 9-thread yarns. Variations in twist of this order are not common in yarn for women's hosiery. The effect of yarn twist on the thickness of the fabric as determined with the compressometer would be even much less.

It is seen from the above that the thickness of the fabric affords a reasonable basis for differentiating between the "weights" of hosiery. On this basis, and on the assumption that the market demands five "weights", the classification given in table 6 is proposed.

TABLE 6.—*Hosiery classification based upon the thickness of two layers of the leg fabric of a stocking*

Proposed weight designation	Thickness of two layers of leg fabric
	Inch
Sheer chiffon	0.012 and less.
Chiffon	0.013 to 0.016, inclusive.
Semiservice	0.017 to 0.020, inclusive.
Service	0.021 to 0.024, inclusive.
Heavy service	0.025 and above.

4. MACHINE TESTS

The hosiery-testing machine[10] consists principally of a pair of jaws, each about 12 inches long, mounted horizontally, parallel to each other, and at such a distance apart that the minimum circumference, that is the distance around the outside of both of them, is 13.3 inches. The stocking to be tested is pulled over these jaws, which are then separated to a maximum circumference of 21.3 inches, and returned to their original position.

This process is repeated at the rate of 60 flexing cycles per minute, alternately distending the stocking and letting it come back. The machine plots the load-elongation curves for the fabric; the curves for

[9] *Silk yarn formation.* Am.Silk and Rayon J. 53, 29 (May 1934).

[10] Herbert F. Schiefer and William D. Appel, *Hosiery-testing machine.* BS J. Research 12, 543 (1934) RP 679.

the first and for the 200th flexing cycles are used for comparison. The total number of flexing cycles required to produce failure is also recorded.

All stockings were laundered before being tested.

(a) DISTENSIBILITY [11]

"*Distensibility*" is defined as the ratio of the increase in circumference to the increase in load when the load is increased from 20 to 30 pounds in the first cycle of the test. It is a measure of the ease with which a new, but laundered, stocking can be distended. If the distensibility is low the stocking may bind and be uncomfortable.

The results of tests are summarized in table 7. It will be noted that the average distensibility for the chiffon stockings was 0.12 inch per pound; for the service stockings 0.13 inch per pound. This shows that the "weight" of the stocking need not be considered in setting a limit for distensibility. The figures also show that there is no relationship between distensibility and price.

The distensibilities of the 239 stockings tested varied from 0.07 to 0.27 inch per pound, with an average of 0.123 inch per pound.

On the assumption that more than one-half of these stockings were satisfactory in regard to this property, it seems advisable to select as a limit a figure somewhat below the average. It is therefore recommended that the distensibility be not less than 0.11 inch per pound.

(b) RECOVERABILITY [12]

"*Recoverability*" is defined as the circumference of the stocking at a load of 30 pounds in the first flexing cycle expressed as a percentage of the circumference at a load of 10 pounds in the 200th flexing cycle. It is a measure of the ability of the stocking to retain its shape after being repeatedly distended. A stocking with low recoverability may be expected to become baggy in service.

The test data in table 7 show that there is no relationship between the recoverability of a stocking and either its "weight" or its price.

The recoverability varied from 86 to 109 percent, the average being 97.6 percent. A stocking which could be distended to a circumference of 18.2 inches by a load of 30 pounds during the first flexing cycle would, after 200 flexing cycles, have so far lost its recoverability that a load of 10 pounds would distend it to a circumference of 18.6 inches on the average. Since it has been assumed that the limiting figure selected should be somewhat below the average, it is recommended that the recoverability be not less than 96 percent.

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[11] This general definition of "distensibility" has been used in this paper instead of the one contained in NBS Research Paper RP753 (see footnote 2, p. 1) because of its greater field of applicability. The relationship between the two definitions for distensibility is approximately linear.

[12] The term "recoverability" has been used in this paper instead of the term "elasticity" because the characteristic evaluated is different from that ordinarily understood by "elasticity." The definition of "recoverability" given above has been used instead of the definition for "elasticity" contained in NBS Research Paper RP753 (see footnote 2, p. 1) because it can be more readily visualized. The relationship between "recoverability" and "elasticity" is linear.

TABLE 7.—*Results of tests with the hosiery-testing machine*

Weight designation	Footnotes	Retail price per pair														Average
		$0.59	$0.69	$0.79	$0.85	$0.88	$0.95	$1.00	$1.15	$1.25	$1.29	$1.35	$1.50	$1.65	$1.95	
Sheer chiffon	a						1,000+									1,000+
	b															
	c						.10									.10
	d						98									98
	e						2									2
Chiffon	a	1,000+	1,000+	1,000+	1,000+(4)	1,000+		1,000+(31)	1,000+	1,000+(9)		1,000+(7)	1,000+(3)	1,000+(4)	1,000+(4)	1,000+(97)
	b				169 (2)		649	421(5)		308(8)	568	254(1)	650(4)	466(12)	647(2)	450(38)
	c	.14	.12	.15	.10	.20	.11	.13	.12	.11	.10	.13	.11	.11	.18	.12
	d	101	99	102	97	103	94	97	99	97	95	99	98	96	104	98
	e	4	11	10	6	2	2	36	8	17	2	8	7	16	6	135
Semichiffon	a							1,000+(2)								1,000+(2)
	b							990(2)								990(2)
	c							.13								.13
	d							97								97
	e							4								4
Service chiffon	a						1,000+									1,000+
	b															
	c						.13									.13
	d						99									99
	e						2									2
Semiservice	a					1,000+	1,000+	1,000+				1,000+				1,000+(16)
	b				414											414(4)
	c				.07	.27	.12	.10				.11				.12
	d				86	109	99	95				95				95
	e				4	2	2	8				4				20
Medium service	a			1,000+						1,000+			1,000+			1,000+(6)
	b				395			544								420(4)
	c			.11	.07			.08		.14			.17			.11
	d			97	92			94		97			103			97
	e			2	2			2		2			2			10
Service	a	1,000+	1,000+	1,000+(6)			1,000+(5)	1,000+(9)	1,000+	1,000+		1,000+	1,000+	1,0000+	1,000+	1,000+(57)
	b			799(2)			129(2)	762(3)								592(7)
	c	.11	.12	.12			.10	.12	.15	.14		.14	.15	.13	.14	.13
	d	94	96	97			97	96	99	102		99	100	97	101	98
	e	4	6	8			7	12	3	4		12	2	4	2	64
Heavy service	a							1,000+								1,000+
	b															
	c							.10								.10
	d							95								95
	e							2								2

Average	a	1,000+	1,000+	1,000+(18)	1,000+(4)	1,000+	1,000+(11)	1,000+(52)	1,000+	1,000+(15)	-------	1,000+(23)	1,000+(7)	1,000+(8)	1,000+(6)	1,000+(184)
	b	--------	--------	799(2)	348(8)	--------	389(4)	622(12)	--------	308(8)	568	254(1)	650(4)	466(12)	647(2)	487(55)
	c	.13	.12	.13	.09	.24	.11	.12	.13	.11	.10	.13	.13	.13	.17	.123
	d	98	98	100	93	106	97	96	99	98	95	98	99	96	103	97.6
	e	8	17	20	12	4	15	64	11	23	2	24	11	20	8	239

(a) "Stretch-endurability" greater than 1,000 flexing cycles.
(b) Average "stretch-endurability" less than 1,000 flexing cycles.
(c) Average "distensibilitiy", inch per pound.
(d) Average "recoverability", percent.
(e) Number of stockings tested. The numbers in parentheses indicate the number of stockings tested which had stretch-endurabilities greater than or less than 1,000 flexing cycles.

(c) STRETCH-ENDURABILITY [13]

"*Stretch-endurability*" is defined as the number of flexing cycles required to produce a failure, that is, a hole or run in the stocking. It is to be expected that a knitted silk fabric is like any other material in that it will ultimately fail when subjected to repeated applications of stress. In service the fabric is stretched more or less every time the wearer's knee is bent; in the machine it is distended from 13.3 to 21.3 inches in each flexing cycle. Eventually this treatment will cause the silk yarn to break. It is characteristic of a knitted fabric that the breaking of the yarn will start a run, which continued stretching will quickly develop into a larger hole.

The machine makes one flexing cycle per second. To test 239 stockings to failure, assuming that each might require 5,000 to 10,000 flexing cycles, seemed likely to be very time-consuming. Fortunately, previous experience had indicated that stockings will either fail at a comparatively small number of flexing cycles or else will last for several thousand. It was therefore decided to stop each test at 1,000 flexing cycles, on the assumption that a stocking which had not failed by that time would withstand a good many more.

The data in table 7 show that 55 of the 239 stockings failed at less than 1,000 flexing cycles. The chiffon group contained a relatively higher proportion of these than the service group, which might be taken to mean that 1,000 flexing cycles is too high a figure for chiffon stockings or too low a figure for service stockings. There is no relationship between stretch-endurability and price.

Since stretch-endurability may be considered a property of major importance in a service stocking, a requirement of 1,000 flexing cycles is probably not too high. It is evidently far below the average, for it was met by 89 percent of the stockings of this group tested. The consumer does not expect as much service from a chiffon stocking, so there is some justification for setting a lower figure for this group. On the other hand, 72 percent of the chiffon stockings tested were able to meet this requirement. This indicates that stockings having this degree of stretch-endurability can be and are being made, even in the lighter weights. It is therefore recommended that the stretch-endurability of a stocking of any weight be set at not less than 1,000 flexing cycles.

5. COLOR FASTNESS TO LAUNDERING

Stockings are laundered frequently, preferably after each wearing. Therefore laundering should not change them unduly in color and appearance. To determine whether or not a stocking can withstand laundering satisfactorily, it is necessary to have a standard laundering test. The method given in NBS Research Paper RP753 is equivalent in severity to perhaps six normal launderings and is recommended for use in hosiery specifications. The stockings thus laundered should show no objectionable change in color and appearance.

[13] The term "stretch-endurability" has been used in this paper instead of the term "endurability" in order to avoid possible confusion of the characteristic evaluated with resistance of the heel, sole, and toe of the stocking to abrasion.

V. MISCELLANEOUS

1. CHECK TESTS

A great variation was found in the results of the different style numbers of a brand, also stockings of the same style number and brand which were purchased three months apart from the same store did not give the same results. The stockings which were purchased at the earlier date had stretch-endurabilities less than 200 flexing cycles, while those which were purchased at the later date had stretch-endurabilities greater than 1,000 flexing cycles. In another instance a number of pairs of stockings of the same style number, brand, color, size, and price were purchased at the same time from one store. It was found that part of these stockings (assuming a 14-inch needle bar) were knit on a 42-gage knitting machine, while the others were either skimped or were knit on a 39-gage knitting machine. There was therefore no assurance that these stockings were degummed, dyed, and finished alike. In view of the effect which these factors have on stockings,[14] it is not surprising that the results of the tests on these stockings were not the same. The stretch-endurability of the 39-gage stocking was 866 flexing cycles and of the 42-gage stocking was greater than 1,500 flexing cycles when the test was discontinued.

TABLE 8.—*Frequency distribution of the stockings with respect to the dimensions of different parts*

Length of welt (in.)	1.5	2	2.5	3	3.5	4	4.5			
Frequency	11	30	10	88	159	109	13			
Width of welt (in.)	5.5	5.75	6	6.25	6.5	6.75	7			
Frequency	6	32	139	155	68	17	2			
Number of fashion marks	0	2	4	6	8	10	12	14	16	18
Frequency	18	0	24	10	60	130	111	28	36	4
Number of wales	345	350	355	360	365	370	375	380	385	390
Frequency	4	22	0	11	12	15	64	71	19	8
Number of wales	395	400	405	410	415	420	425	430	435	440
Frequency	3	10	102	42	6	0	0	5	6	1
Number of wales	445	450	455	460	465	470	475	480		
Frequency	0	1	2	9	6	0	0	4		
Length of heel (in.)	1.5	1.75	2	2.25	2.50	2.75	3			
Frequency	2	41	189	155	33	5	1			
Width of heel, (in.)	1	1.25	1.50	1.75	2					
Frequency	2	65	178	149	28					
Length of high heel (in.)	1.5	1.75	2	2.25	2.50	2.75	3	3.25		
Frequency	1	12	92	157	114	35	13	2		
Width of high heel (in.)	.25	.50	.75	1	1.25					
Frequency	3	171	225	16	7					
Length of toe (in.)	2	2.25	2.50	2.75	3	3.25				
Frequency	12	86	178	124	21	3				
Width of toe (in.)	2.75	3	3.25							
Frequency	26	256	142							
Width of sole (in.)	.50	.75	1	1.25	1.50					
Frequency	7	110	189	83	5					

[14] Herbert F. Schiefer and Richard S. Cleveland, *Factors affecting the performance of hosiery on the hosiery-testing machine.* NBS J.Research 14, 1 (1935) RP753.

2. DIMENSIONS OF PARTS

In figure 1, various parts are indicated besides those for size and length. The frequency distributions of the dimensions of these parts for the stockings measured are given in table 8. Since some of these parts are style factors, while others are of different importance to different consumers, it is felt that any attempt to standardize them might be out of place. The data are therefore presented merely as information.

3. OTHER TESTS

There seems to be a growing demand for information about two other properties of hosiery (1) the ability of the heels and toes to resist abrasion, and (2) the ability of the fabric in the leg to resist snagging. Work is at present under way, both at this Bureau and elsewhere, to develop methods of test for these properties.

VI. SUMMARY

Based on the above data, the following recommendations are made:

The size of the stocking should be as specified, with a plus tolerance of 0.5 inch.

Unless otherwise specified, the length of the stocking should be 30 inches, plus or minus 1 inch.

The weight designation of the stocking should be based upon the thickness of the fabric, using the classification suggested in table 6.

The "distensibility" of the laundered stocking should be not less than 0.11 inch per pound.

The "recoverability" of the laundered stocking should be not less than 96 percent.

The "stretch-endurability" of the laundered stocking should be not less than 1,000 flexing cycles.

When laundered by the method described, the stocking should show no objectionable change in color or appearance.

WASHINGTON, March 1, 1935.

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